

What is Claimed:

1. In digital wireless communication system, the digital wireless communication system including a plurality of elements comprising a plurality of mobile stations, a plurality of base transceiver stations, each of the plurality of base transceiver stations in communication with at least one of the plurality of mobile stations, a transcoder configured to provide a signal conversion capability between vocoder frames and pulse code modulation, and a mobile switching center for interconnecting the digital wireless communication system to a public switched telephone network, a method for determining a fault in a digital channel of the digital wireless communication system, the method comprising:

(a) generating a first set of vocoder input parameters, the first set of vocoder input parameters resulting from a speech input signal;

(b) generating a second set of vocoder input parameters, the second set of vocoder input parameters resulting from an output signal substantially equivalent to the speech input signal as it is received at a mobile station via the digital channel;

(c) calculating a metric based on the first set of vocoder input parameters and the second set of vocoder input parameters; and

(d) determining a fault in the digital channel using the metric.

2. The method for determining a fault in a digital channel according to claim 1, wherein the step of generating the first set of vocoder input parameters comprises vocoder encoding a speech signal to form the speech input signal.

3. The method for determining a fault in a digital channel according to claim 2, wherein the step of generating the first set of vocoder input parameters further comprises simulating the speech signal by generating m frames of a vowel sound followed by m frames of silence followed by m frames of the vowel sound followed by m frames of silence.

4. The method for determining a fault in a digital channel according to claim 1, wherein the step of transmitting the speech input signal to a mobile station further comprises:

vocoder decoding the speech input signal to form a pulse code modulation signal;
transmitting the pulse code modulation signal through the mobile switching center to form a switched pulse code modulation signal;

vocoder encoding the switched pulse code modulation signal to form a vocoder re-encoded speech input signal, the vocoder re-encoded speech input signal substantially equivalent to the speech input signal having been vocoder decoded and re-encoded; and
transmitting the vocoder re-encoded speech input signal to the mobile station.

5. The method for determining a fault in a digital channel according to claim 1, wherein the step of calculating the metric comprises:

extracting a first plurality of groups of line spectrum pair (LSP) frequencies from the first set of vocoder input parameters, the first plurality of groups comprising groups of ten LSP frequencies per group;

extracting a second plurality of groups of LSP frequencies from the second set of vocoder input parameters, the second plurality of groups comprising groups of ten LSP frequencies per group;

calculating a multiplicity of frame correlation error (FCE) metrics utilizing the first plurality of groups of LSP frequencies and the second plurality of groups of LSP frequencies;

selecting the FCE metric having the smallest value from among the multiplicity of FCE metrics to form a minimum FCE value, the minimum FCE value indicating optimum alignment of the speech input signal with the output signal; and

comparing the minimum FCE value to a threshold value, the minimum FCE value indicating a fault in the digital channel if the minimum FCE value is greater than the threshold value.

6. The method for determining a fault in a digital channel according to claim 5, further comprising:

generating a plurality of fingerprint fault values, wherein the plurality fingerprint fault values are experimentally predetermined, and wherein each of the fingerprint fault values corresponds to a faulty element of the digital channel;

comparing the minimum FCE value to the plurality of fingerprint fault values; and
determining the faulty element of the digital channel based on the comparison.

7. The method for determining a fault in a digital channel according to claim 6, wherein the element is a noisy terrestrial circuit selected by the mobile switching center, and wherein the fingerprint fault value is substantially equivalent to a minimum FCE value greater than or equal to a value about 50 percent higher than the threshold value.

8. The method for determining a fault in a digital channel according to claim 6, wherein the element is a dead channel element of a base transceiver station of the digital channel, and wherein the fingerprint fault value is substantially equivalent to a minimum FCE value up to about a value of 50 percent higher than the threshold value.

9. The method for method for determining a fault in a digital channel according to claim 5, wherein the step of calculating the multiplicity of frame correlation error metrics comprises:

(a) aligning the first group of the first plurality of groups with the first group of the second plurality of groups;

(b) calculating a difference between each of the ten LSP frequencies from the first group of the first plurality of groups and each of the corresponding ten LSP frequencies from the first group of the second plurality of groups to form ten LSP difference values;

(c) squaring each of the ten LSP difference values to form ten squared LSP values;

(d) multiplying each of the ten LSP values by a corresponding weight factor value to form ten weighted LSP values;

(e) summing together each of the ten weighted LSP values to form a sum LSP value;

(f) dividing the sum LSP value by ten to form a mean LSP value;

(g) calculating a square root of the mean LSP value to form a frame correlation error metric of the multiplicity of frame correlation error metrics;

(h) realigning the next group of the first plurality of groups with the first group of the second plurality of groups; and

(i) repeating steps (a) through (h) until the first group of the second plurality of groups is aligned with a midpoint group of the first plurality of groups, the midpoint group marking the midpoint of the first plurality of groups.

10. The method for determining a fault in a digital channel according to claim 9, wherein the weight factor values are preselected based on a ranking of importance to a listener and correspond to the LSP frequencies used to calculate the difference.

11. The method for method for determining a fault in a digital channel according to claim 5, wherein the step of calculating each of the plurality of frame correlation error metrics comprises calculating:

$$\sqrt{\frac{\sum_{i=10} W(i) [LSP_{out}(i) - LSP_m(i)]^2}{10}} = \text{Frame Correlation Error Metric}$$

wherein, i is the value 10, $LSP_{out}(i)$ is a group of 10 LSP frequencies from the second plurality of LSP frequencies, each of the 10 LSP frequencies having a value denoted as (i) , and $LSP_m(i)$ is a group of 10 LSP frequencies from the first plurality of LSP frequencies, each of the 10 LSP frequencies having a value denoted as (i) , and $W(i)$ is a weight factor value, each of the weight factor values pre-selected for each of the 10 LSP frequencies.

12. The method for determining a fault in a digital channel according to claim 11, wherein the weight factor values are preselected based on a ranking of importance to a listener and correspond to the LSP frequencies used to calculate the difference.

13. An apparatus for determining a fault in a digital channel of a digital wireless communication system, the apparatus comprising:

(a) a source test mobile station configured to generate a first set of vocoder input parameters, the first set of vocoder input parameters resulting from vocoder encoding a speech signal received by the source test mobile station to form a speech input signal;

(b) a transcoder configured to generate a second set of vocoder input parameters, the second set of vocoder input parameters resulting from an output signal substantially equivalent to the speech input signal as it is received at a destination test mobile station via the digital channel; and

(c) a frame correlation error generator configured to calculate a metric based on the first set of vocoder input parameters and the second set of vocoder input parameters, and determine a fault in the digital channel using the metric.

14. The apparatus for determining a fault in a digital channel according to claim 12, wherein the speech signal is m frames of a vowel sound followed by m frames of silence followed by m frames of the vowel sound followed by m frames of silence.

15. The apparatus for determining a fault in a digital channel according to claim 12, wherein the transcoder is further configured to

vocoder decode the speech input signal to form a pulse code modulation signal;

transmit the pulse code modulation signal to the mobile switching center to form a switched pulse code modulation signal;

receive the switched pulse code modulation signal from the mobile switching center;

vocoder encode the switched pulse code modulation signal to form a vocoder re-encoded speech input signal, the vocoder re-encoded speech input signal substantially equivalent to the speech input signal having been vocoder decoded and re-encoded; and transmit the vocoder re-encoded speech input signal to the mobile station.

16. The apparatus for determining a fault in a digital channel according to claim 12, wherein the frame correlation error generator further comprises:

a line spectrum pair (LSP) frequency extractor module configured to extract a first plurality of groups of LSP frequencies from the first set of vocoder input parameters and a second plurality of groups of LSP frequencies from the second set of vocoder input parameters, the first plurality of groups comprising groups of ten LSP frequencies per group and the second plurality of groups comprising groups of ten LSP frequencies per group;

a frame aligner module configured to align the first group of the first plurality of groups of LSP frequencies with the first group of the second plurality of groups of LSP frequencies;

a frame correlation calculator configured to calculate a multiplicity of frame correlation error (FCE) metrics utilizing the first plurality of groups of LSP frequencies and the second plurality of groups of LSP frequencies;

a frame correlation selector module configured to select the FCE metric having the smallest value from among the multiplicity of FCE metrics to form a minimum FCE value, the minimum FCE value indicating optimum alignment of the speech input signal with the output signal; and

a threshold indicator configured to compare the minimum FCE value to a threshold value, the minimum FCE value indicating a fault in the digital channel if the minimum FCE value is greater than the threshold value.

17. The apparatus for determining a fault in a digital channel according to claim 15, wherein the frame correlation calculator is further configured to calculate each of the multiplicity of frame FCE metrics utilizing an equation:

$$\sqrt{\frac{\sum_{i=10} W(i) [LSP_{out}(i) - LSP_m(i)]^2}{10}} = \text{Frame Correlation Error Metric}$$

wherein, i is the value 10, $LSP_{out}(i)$ is a group of 10 LSP frequencies from the second plurality of LSP frequencies, each of the 10 LSP frequencies having a value denoted as (i) , and $LSP_m(i)$ is a group of 10 LSP frequencies from the first plurality of LSP frequencies, each of the 10 LSP frequencies having a value denoted as (i) , and $W(i)$ is a weight factor value, each of the weight factor values pre-selected for each of the 10 LSP frequencies.